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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

2-4-9

Seismic monitoring of the RULISON underground
nuclear explosion near Rifle, Colorado, on
10 September 1969

by

R. M. Hamilton, B. E. Smith and J. H. Healy

Open-File Report
1970

This report is preliminary and has not
been edited or reviewed for conformity
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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
National Center for Earthquake Research
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Menlo Park, California 94025

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16 February 1970

Memorandum

TO: Distribution List

FROM: L. C. Pakiser, Chief, Office of Earthquake
Research and Crustal Studies

SUBJECT: Seismic effects of RULISON

Seismic waves from the RULISON underground nuclear explosion of September 10, 1969, were recorded by 30 seismic units of the U.S. Geological Survey along lines extending westward to the Pacific coast and southwestward to Lake Isabella, California, as a part of our continuing seismic investigation of the structure of the earth's crust and upper mantle. Five seismograph stations within 15 km of ground zero monitored seismic activity at the RULISON site from 72 hours before until 18 hours after the explosion. We consider the earthquake activity, as described in the attached report by R. M. Hamilton, B. E. Smith, and J. H. Healy, to be insignificant in terms of potential seismic hazards.

This report has been placed in the open files of the U.S. Geological Survey.

L. C. Pakiser
L. C. Pakiser

UNITED STATES
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Seismic Monitoring of the RULISON
Underground Nuclear Explosion near
Rifle, Colorado, on 10 September 1969

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Seismic monitoring of the RULISON underground nuclear
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R. M. Hamilton, B. E. Smith, and J. H. Healy*

Five seismograph stations located within 15 km of ground zero monitored seismic activity at the RULISON site from 72 hours before until 18 hours after the explosion. No earthquakes were recorded in the period preceding the shot; 16 were recorded after the shot, all within the first 43 minutes. These aftershocks, all of which had Richter magnitude of less than 1, were located within 1 km of the explosion.

Portable seismograph systems (Eaton et al., in press) were centered around ground zero (Fig. 1 and Table 1). Recorded earthquakes were located by the computer program HYPOLAYR (Eaton, 1969 and Eaton et al., in press) using a crustal model (Table 2) derived from Jackson and Pakiser (1965). The epicenters of the 16 earthquakes detected (Table 3) are shown in Figure 2. The fact that both compressional and dilatational first motions were recorded for the 16 aftershocks indicates that a simple volume change did not cause the aftershocks, as would have been the case for cavity relaxation.

The seismograms showed numerous signals similar to the emergent seismic events observed after underground explosions at Nevada Test Site and believed to be associated with cavity deterioration. The signals in the Rulison area, however, were observed before as well as after the detonation, thus ruling out cavity deterioration as the cause. They are believed to have been caused by vehicular traffic.

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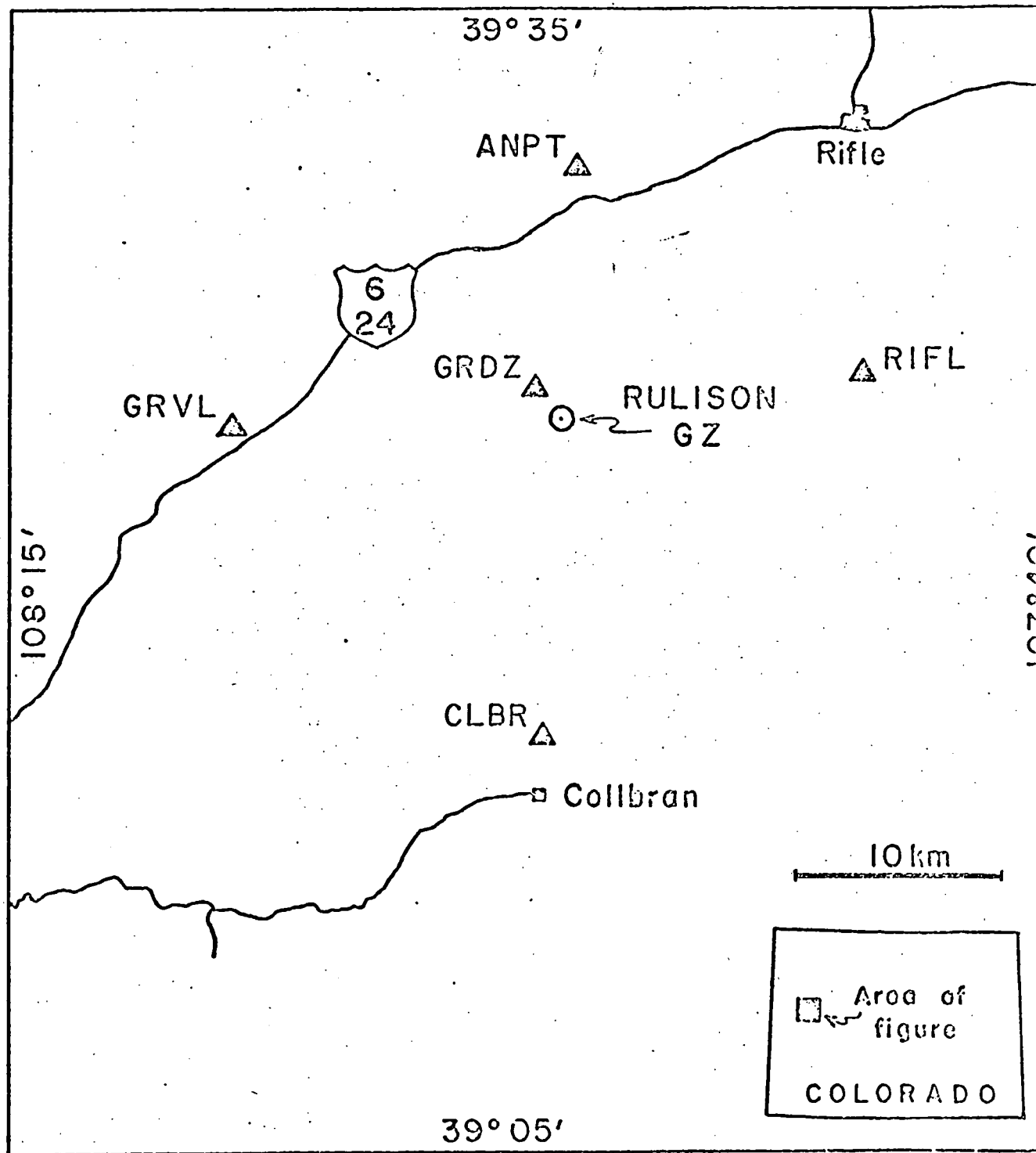


Figure 1. Map of the Rifle, Colorado, area showing the RULISON site location and seismograph station locations (triangles).

Table 1. Seismograph station locations and arrival time corrections

| <u>Station name</u> | <u>Latitude, N.</u> <u>deg min</u> | <u>Longitude, W.</u> <u>deg min</u> | <u>Elevation,</u> <u>m</u> | <u>Station*</u> <u>correction</u> |
|---------------------|---------------------------------------|--|-------------------------------|--------------------------------------|
| GRDZ | 39 25.10 | 107 57.61 | 2,271 | -0.09 |
| ANFT | 39 30.92 | 107 56.22 | 1,993 | 0.15 |
| CLBR | 39 15.65 | 107 57.31 | 1,963 | 0.24 |
| GRVL | 39 24.00 | 108 07.77 | 1,573 | 0.17 |
| RIFL | 39 25.67 | 107 46.67 | 2,220 | 0.27 |

* Station corrections, which are added to the observed arrival times, were derived from the P-wave arrival times of RULISON.

Table 2. Crustal model used for locating the RULISON aftershocks

| <u>Velocity,</u> <u>km/sec</u> | <u>Depth to top of layer,</u> <u>km</u> |
|-----------------------------------|--|
| 4.00 | 0.0 |
| 6.05 | 3.0 |
| 6.85 | 23.5 |
| 7.90 | 42.5 |

Table 3. Origin times, locations and magnitudes of RULISON aftershocks, 10 September 1969 (GMT)

| Origin time, | | | Latitude, N. | | Longitude, W. | | Depth, | Magnitude | Number Stations |
|--------------|-----|-------|--------------|-------|---------------|-------|--------|-----------|--------------------|
| hr | min | sec | deg | min | deg | min | km | | |
| 21 | 07 | 01.17 | 39 | 23.66 | 107 | 56.90 | 1.9 | 0.3 | 3 |
| | 08 | 39.26 | | 24.38 | | 56.80 | 2.5 | 0.6 | 4 |
| | 09 | 38.49 | | 24.21 | | 56.91 | 2.4 | 0.4 | 4 |
| | 10 | 43.82 | | 24.47 | | 56.82 | 2.3 | 0.6 | 5 |
| | 11 | 26.11 | | 24.06 | | 56.76 | 2.3 | 0.3 | 4 |
| | 12 | 16.30 | | 24.50 | | 56.84 | 2.5 | 0.8 | 5 |
| | 13 | 07.21 | | 24.29 | | 56.81 | 2.2 | 0.0 | 4 |
| | 13 | 53.20 | | 24.45 | | 56.77 | 2.5 | 0.7 | 5 |
| | 14 | 54.31 | | 24.30 | | 56.66 | 2.6 | 0.6 | 3 |
| | 16 | 05.51 | | 24.77 | | 57.36 | 2.4 | 0.4 | 4 |
| | 18 | 18.89 | | 24.24 | | 56.82 | 2.2 | 0.3 | 4 |
| | 19 | 04.90 | | 24.42 | | 56.77 | 2.5 | 0.6 | 5 |
| | 19 | 53.48 | | 24.39 | | 56.78 | 2.4 | 0.6 | 4 |
| | 28 | 39.75 | | 24.30 | | 56.90 | 2.6 | 0.3 | 4 |
| | 32 | 12.76 | | 24.25 | | 56.76 | 2.6 | 0.4 | 3 |
| | 42 | 20.42 | | 24.31 | | 56.79 | 2.3 | 0.5 | 4 |

RULISON

| | | | | | | | | |
|----|----|-------|----|-------|-----|-------|-----|-----|
| 21 | 00 | 00.11 | 39 | 24.35 | 107 | 56.88 | 2.6 | 5.0 |
|----|----|-------|----|-------|-----|-------|-----|-----|

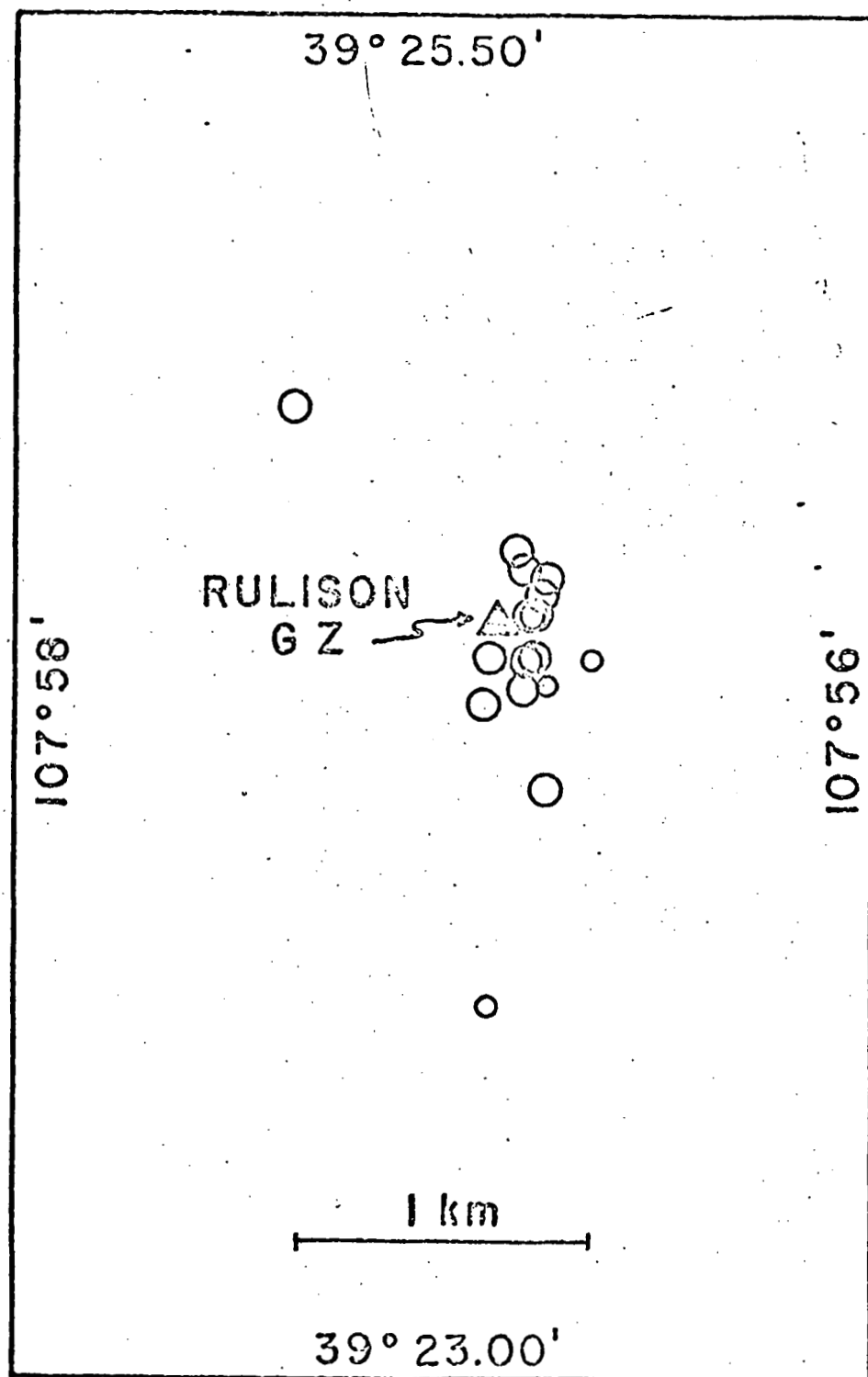


Figure 2. Epicenter map of the RULISON aftershocks. Large circles represent events located by 4 or 5 stations, small circles represent events located by only 3 stations.

REFERENCES

- Eaton, J. P., 1969, HYPOLAYR, a computer program for determining hypocenters of local earthquakes in an earth consisting of uniform flat layers over a half space, U. S. Geological Survey Open File Report, 106 p.
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- Jackson, W. H., and L. C. Pakiser, 1965, Seismic study of crustal structure in the southern Rocky Mountains: US Geol. Survey Prof. Paper 525-D, pages D85-D92.